

# CALCAREOUS NANNOFOSSILS AND PLANKTIC FORAMINIFERS IN TERTIARY LIMESTONES, NATAL AND EASTERN CAPE, SOUTH AFRICA

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(With 12 figures)

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## ABSTRACT

Sixteen taxa of Palaeogene calcareous nannofossils and seven of planktic foraminifers have been identified in limestones from the eastern Cape Province. Four taxa of Neogene calcareous nannofossils and nine of planktic foraminifers have been found in limestones from Zululand.

The assemblages indicate that the limestones at Birbury are lower Eocene, and suggest a probable Eocene age for the limestones in the upper quarry at Needs Camp. Nannofossils and planktic foraminifers confirm that the limestones north of the Umfolozi River in Zululand are upper Miocene–lower Pliocene.

The Birbury and Zululand dates reflect the mid Paleocene–early Eocene and late Miocene–early Pliocene transgressions round South Africa. The Tertiary limestones at Needs Camp could have been deposited during either the early or the late Eocene transgression.

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## INTRODUCTION

Tertiary limestones are exposed intermittently along the coast of the Cape Province from at least Saldanha Bay in the west to East London in the east. A second belt of limestones crops out intermittently from near the Umfolozi River in Natal Province ('Zululand') northward into Mozambique (Fig. 1).

These limestones are not well dated, despite the efforts of numerous investigators. Age assignments of certain outcrops in the eastern Cape and

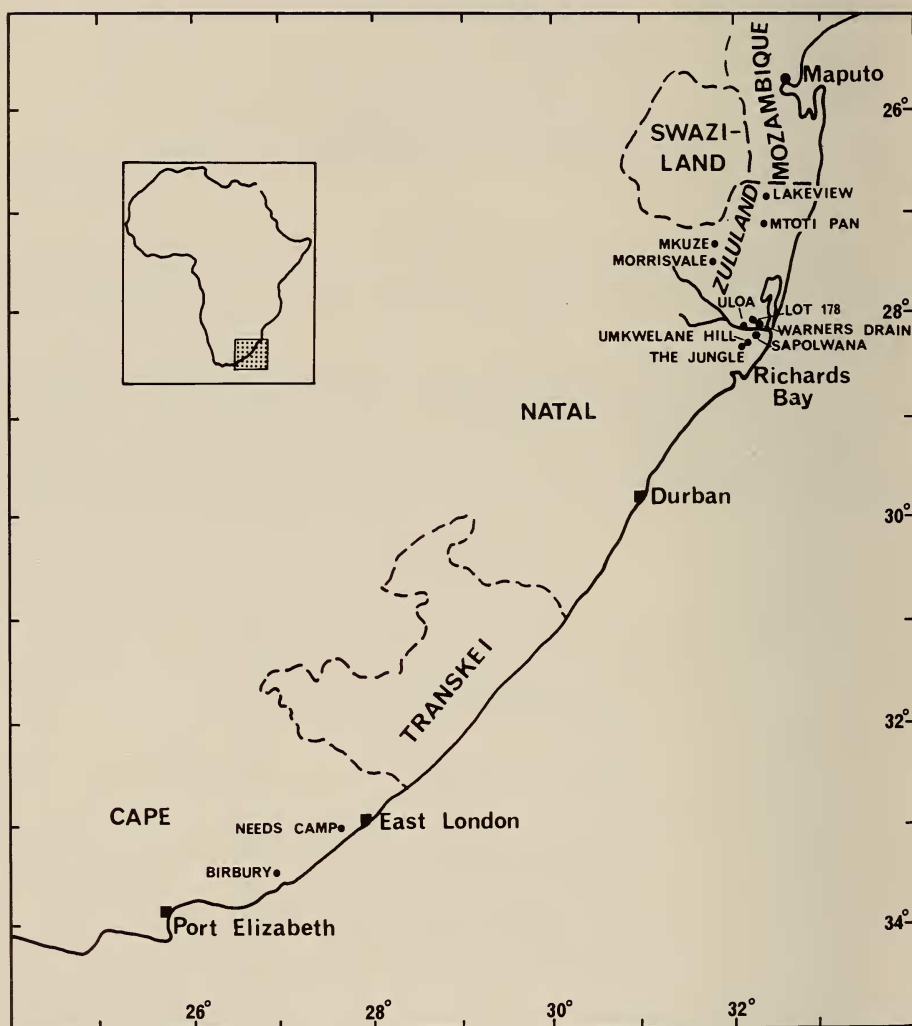


Fig. 1. Location map showing the outcrop localities of the marine Tertiary limestones mentioned in the text.

Natal are especially contentious. Most earlier workers relied on molluscs, echinoderms, benthic foraminifers or sharks' teeth as the bases for their age assignments. The first three groups of animals are strongly facies controlled and are not particularly good for narrow age determinations. Nor are sharks' teeth very suitable, since their stratigraphic usefulness suffers from a lack of precisely known age ranges for different species.

Planktic foraminifers and calcareous nannofossils are the two groups most widely used for high-resolution Tertiary biostratigraphy today. They have several advantageous characteristics: (i) they are very abundant in marine sediments, (ii) their evolution has been rapid, which allows establishment of many narrow and discrete zones on the basis of morphotypes, and (iii) as floating organisms they are widely distributed and thus are useful for interregional correlations. Planktic foraminifers from some of the outcrops described in this study have been investigated in recent years, and several of the former age assignments have already been modified (especially in Zululand). Calcareous nannofossils have not previously been reported from any of these rocks.

The purposes of this paper are (i) to record the nannofossils and planktic foraminifers present in these Tertiary limestones, (ii) to assess the ages of the rocks, based on the nannofossils and foraminifers, and (iii) to comment on Tertiary sea-level movements round South Africa in the light of the ages now assigned to the limestones.

### BIRBURY

Only cursory remarks on the lithology of the Birbury section (Fig. 1) have previously been published. Figure 2 shows a stratigraphic section measured by one of us (WGS) at Birbury. The section is exposed in an abandoned quarry near the Birbury homestead. It consists of 1 to 1.5 m of calcareous conglomerate and coarse calcarenite, overlain by about 3 m of fine to medium calcarenite which becomes increasingly nodular and 'chalky' up section. The limestones contain scattered sharks' teeth and mollusc, echinoid and bryozoan fragments. The general lithology of this outcrop is not similar to the Tertiary Alexandria Formation extensively exposed to the west (see measured sections in Siesser 1972), nor to the Needs Camp exposures to the east.

Chapman (1930) examined ten thin sections of the Birbury limestones which were sent to him by Haughton in 1925. Chapman noted the presence of '... beautifully preserved and abundant tests of *Discocyclina pratti* and *D. varians* ...'. Chapman (1930) assigned the rocks to the upper Eocene on the basis of the more abundant of the two species, *D. pratti*, which he stated '... is a well-recognized Bartonian species'. He also mentioned that the less numerous *D. varians* seemed to indicate a slightly lower horizon (upper Lutetian, i.e. middle Eocene). More recent investigations have extended the age range of *D. pratti*, and it is now known to occur from the Paleocene through the Eocene (D. Salmon, pers. comm. 1978).

Nevertheless, an Eocene age seemed evident and was widely accepted until

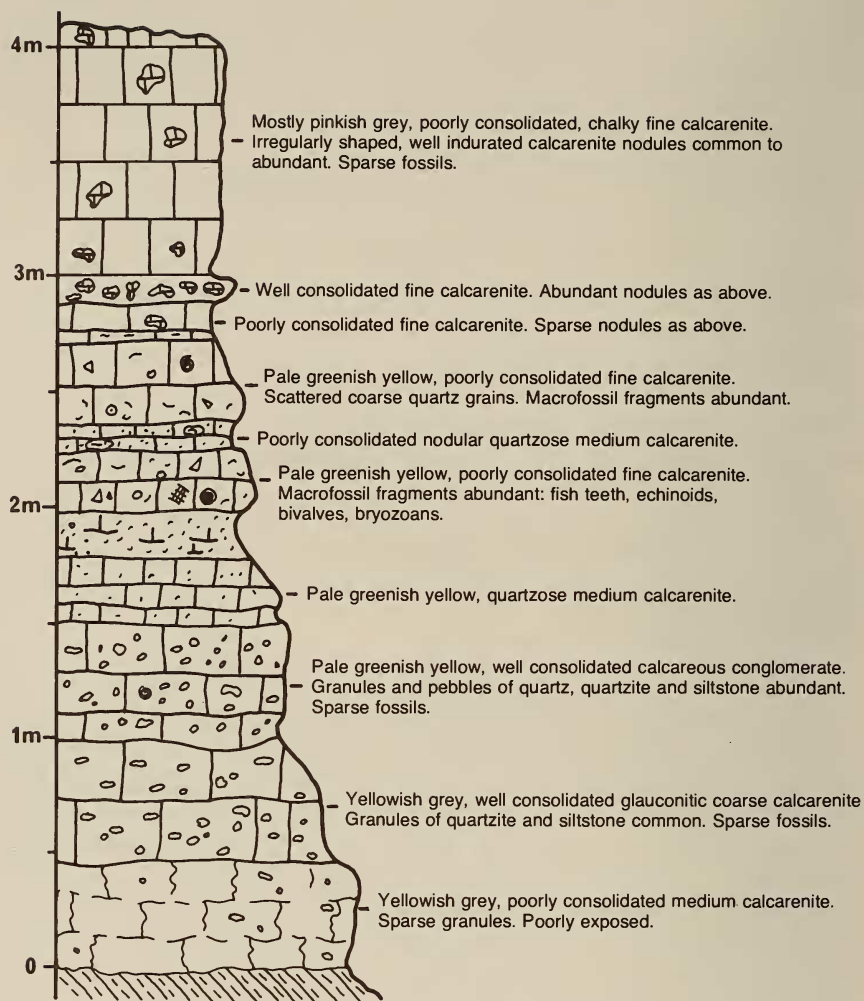


Fig. 2. Stratigraphic section of lower Eocene limestones at Birbury, eastern Cape Province, 33°28'18"S 26°55'30"E. Base of the section is about 205 m above sea-level. Colours are from the Geological Society of America Rock-Color Chart.

Bourdon & Magnier (1969) reported their investigation of the foraminifers at Birbury. Largely on the basis of test preservation, they concluded that two different assemblages are present at Birbury: (i) an abundant, but poorly preserved Eocene fauna represented by at least twenty taxa, and (ii) a sparse, but well-preserved Miocene fauna represented by five species of benthic foraminifers. They, therefore, assigned the rocks to the Miocene, suggesting that the



diverse and abundant Eocene foraminifers were reworked (but correctly noted that such a mixture was 'quite remarkable').

Their Miocene age assignment seems to have been uncritically accepted by most interested workers in South Africa, even though Bourdon & Magnier's five 'Miocene' species were not conclusively identified (all were listed as 'cf'). Moreover, even if the identifications of these five species had been definite, it seems somewhat presumptuous to assign a Miocene age on the basis of such long-ranging forms as *Cibicides lobatulus* (Eocene to Holocene) and *Lagena gibbera* (? Eocene to Holocene). Finally, Bourdon & Magnier (1969: 123) point out that their colleagues at the Paris Museum examined sharks' teeth from the same samples and assigned them to the lower Eocene.



Fig. 3. Quarry face at Birbury. Pebble conglomerate at bottom of photograph. Hammer lies near top of fossiliferous calcarenite. Nodular, 'chalky' zone at top of photograph.

*Calcareous nannofossils* (Fig. 4)

Very rare, poorly preserved nannofossils occur throughout the section at Birbury. However, only a poorly consolidated fossiliferous layer about 2 m above the base contains nannofossils in sufficient numbers and with adequate preservation to justify study. Species present include:

- Braarudosphaera bigelowi* (Gran & Braarud)
- Chiasmolithus solitus* (Bramlette & Sullivan)
- Chiasmolithus* sp.
- Coccolithus eopelagicus* (Bramlette & Riedel)
- Coccolithus formosus* (Kamptner)
- Cruciaplacolithus* sp.
- Cyclococcolithus gammatum* Bramlette & Sullivan
- Discoaster* sp.
- ? *Lophodolitus nascens* Bramlette & Sullivan
- Pontosphaera* spp.
- Reticulofenestra coenura* (Reinhardt)
- Transversopontis pulcher* (Deflandre)
- Zygodiscus plectopons* Bramlette & Sullivan
- Zygrhablithus bijugatus* (Deflandre)

*Planktic foraminifers* (Figs 4-6)

A sparse population of planktic foraminifers is found throughout the section, but the best assemblage occurs in a fossiliferous layer about 2,5 m above the base. The following species were identified in the series of samples collected at Birbury:

- Acarinina esnaensis* (LeRoy)
- A. nitida* (Martin)
- A. primitiva* (Finlay)
- A. pseudotopilensis* Subbotina
- A. soldadoensis soldadoensis* (Bronnimann)
- Morozovella subbotinae* (Morozova)
- Subbotina eoacena* (Gümbel)

*Age*

The nannofossil assemblage is clearly Palaeogene. *Cruciaplacolithus* sp., *Cyclococcolithus gammatum*, *Lophodolitus nascens* and *Zygodiscus plectopons* all range from Paleocene to Eocene, and *Coccolithus formosus*, *Reticulofenestra coenura* and *Zygrhablithus bijugatus* range from Eocene to Oligocene. *Transversopontis pulcher* is probably restricted to the Eocene, and *Chiasmolithus solitus* occurs only in the lower and middle Eocene. *Braarudosphaera bigelowi* and *Coccolithus eopelagicus* range throughout the Tertiary.

The planktic foraminifers also indicate a Palaeogene age. *Acarinina esnaensis*, *A. nitida*, *A. pseudotopilensis* and *A. soldadoensis soldadoensis* all range

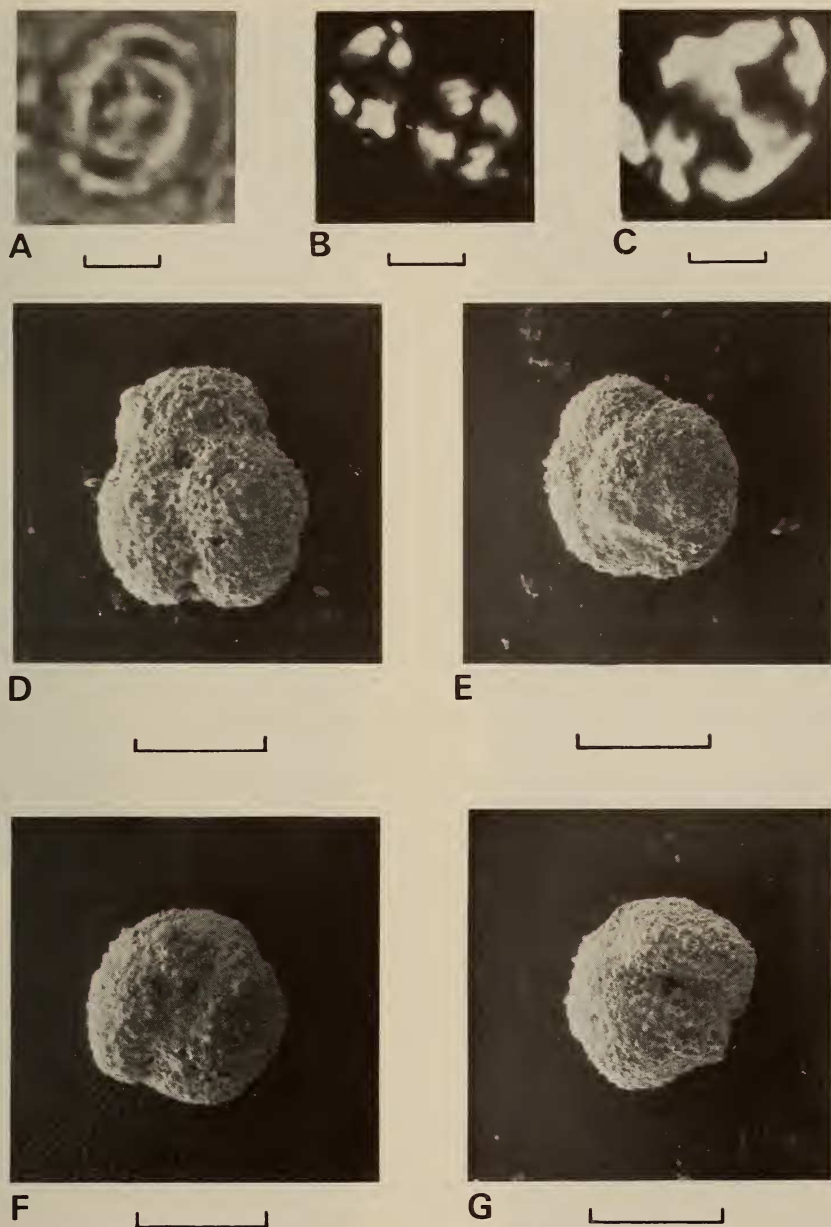
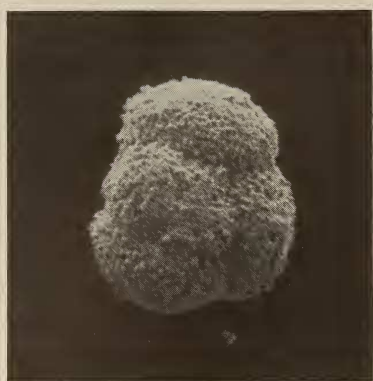


Fig. 4. Calcareous nannofossils and planktic foraminifers from Birbury (lower Eocene). A. *Chiasmolithus* sp., plane polarized light, scale =  $6\mu$ . B. *Coccolithus formosus* (right) and *Pontosphaera* sp. (left), crossed nicols, scale =  $8\mu$ . C. *Transversopontis pulcher*, crossed nicols, scale =  $5\mu$ . D. *Acarinina esnaensis*, spiral view, SAM-K5542. E-G. *A. nitida*. E. Spiral view, SAM-K5543. F. Umbilical view, SAM-K5544. G. Side view, SAM-K5544. Scales D-G =  $200\mu$ .



A



B



C



D



E



F

Fig. 5. Planktic foraminifers from Birbury (lower Eocene). A-C. *Acarinina primitiva*. A. Spiral view, SAM-K5545. B. Umbilical view, SAM-K5546. C. Side view, SAM-K5547. D. *A. pseudotopilensis*, spiral view, SAM-K5548. E-F. *A. soldadoensis soldadoensis*. E. Spiral view, SAM-K5549. F. Umbilical view, SAM-K5550. Scales = 200 $\mu$ .



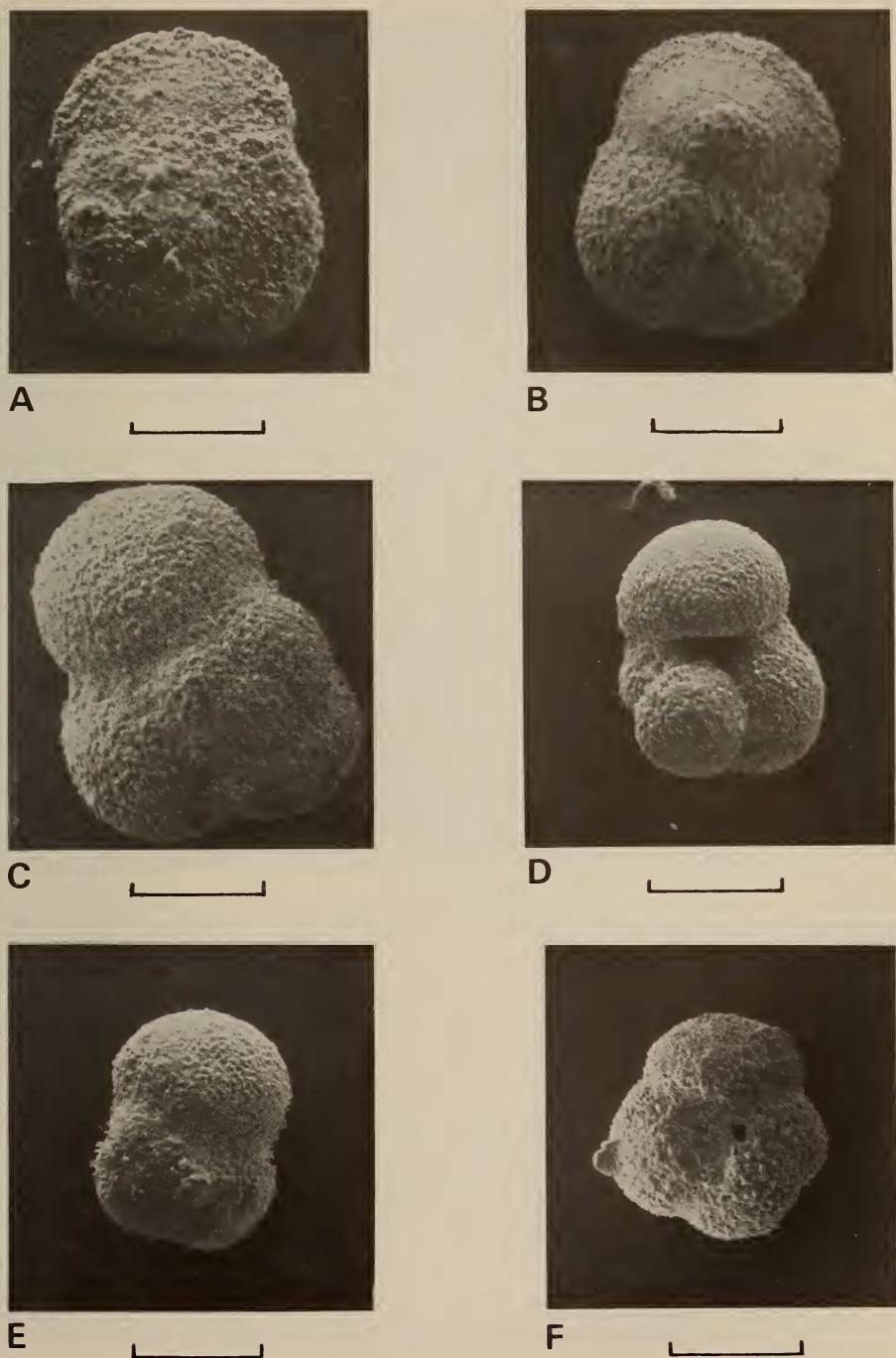


Fig. 6. Planktic foraminifera from Birbury (lower Eocene). A-B. *Morozovella subbotinae*. A. Spiral view, SAM-K5551. B. Umbilical view, SAM-K5551. C-E. *Subbotina eocaena*. C. Spiral view, SAM-K5552. D-E. Umbilical views, SAM-K5553, SAM-K5554. F. *Acarinina soldadoensis soldadoensis*, umbilical view, SAM-K5555. Scales = 200 $\mu$ .



from upper Paleocene to lower Eocene, *A. primitiva* ranges from upper Paleocene to middle Eocene, *Subbotina eocaena* from lower Eocene to lower Oligocene, and *Morozovella subbotinae* is restricted to the lower Eocene.

It is difficult to believe that these diverse Palaeogene assemblages of calcareous nannofossils and planktic foraminifers are entirely the result of reworking, especially since not one strictly Neogene nannofossil or foraminifer was found in the section. The section is, therefore, assigned to the lower Eocene, based on the overlapping ranges of various species of planktic foraminifers and calcareous nannofossils. The presence of *M. subbotinae* corroborates the age and allows assignment to Berggren & Van Couvering's (1974) planktic foraminiferal Zones P6 to P8 (54,5 to 50 m.y.B.P.; years from Hardenbol & Berggren 1978).

### NEEDS CAMP

Marine limestones crop out in two quarries near Needs Camp (Fig. 1). The lower quarry contains limestones, which, on the basis of calcareous nannofossils, are probably upper Campanian to lower Maestrichtian (Siesser, unpublished data). The upper quarry is about 17 m above the lower quarry, and the contact between the limestone units in the two quarries is not exposed.

The exposed section in the upper quarry is about 4 m thick; it is a hard, recrystallized, coarse calcarenite which becomes more flaggy towards the top (Fig. 7). The calcarenite is mostly yellowish-grey 5Y 7/3 (GSA Rock Color Chart) on fresh surfaces but weathers to a darker grey. A thin section of the calcarenite shows it is a skeletal grainstone, rich in the remains of molluscs, cirripeds, bryozoans and coralline algae, cemented by microspar (Siesser 1971). Large *Perna* valves are conspicuous in these rocks. Additional notes on the lithology of the upper quarry are found in Lock (1973).

The limestones in the upper quarry were originally correlated with the Alexandria Formation (Bullen-Newton 1913; Du Toit 1954). An Eocene age was proposed for part of the Alexandria Formation, based on the identification of upper Eocene foraminifers (Chapman 1930) and sharks' teeth (Haughton 1925) at Birbury. Haughton (1969), therefore, suggested an Eocene age for the upper quarry in his textbook on South African geology. King (1972) considered both quarries to be Upper Cretaceous, based on fossil and geomorphic evidence. Lock (1973) reviewed the literature in detail with regard to the dating of the upper quarry. He concluded, again, that these rocks are Tertiary, but did not assign them to a specific series. Lock (pers. comm. 1977) believes the upper quarry could be as young as Miocene, based on the presence of *Carcharodon angustidens*. (This shark is, however, now known to range from middle Eocene to Pliocene (Jubb & Gardiner 1975).)

### Calcareous nannofossils (Fig. 8)

Most of the rocks in the upper quarry are too recrystallized to yield identifiable nannofossils; only a few heavily overgrown species (*Coccolithus*



Fig. 7. Calcarenite in the upper quarry at Needs Camp, eastern Cape Province. Probably Eocene.

*eopelagicus*, *Cyclococcolithus gammatum* and *Toweius* sp.) were found in a soft layer about 1,75 above the base of the exposure.

A slightly better assemblage was found in a calcareous siltstone from a pit dug below the exposed base of the outcrop. This sample was collected and made available by B. E. Lock. The sample contains a mixture of poorly to moderately preserved Upper Cretaceous and Tertiary species. Extensive reworking of the nannofossil-rich underlying beds is obvious, since Upper Cretaceous specimens outnumber Tertiary specimens by a ratio of about 10 to 1 in the siltstone. The following Tertiary species are present:

- Braarudosphaera bigelowi* (Gran & Braarud)
- Chiasmolithus* cf. *C. solitus* (Bramlette & Sullivan)
- Coccolithus eopelagicus* (Bramlette & Riedel)

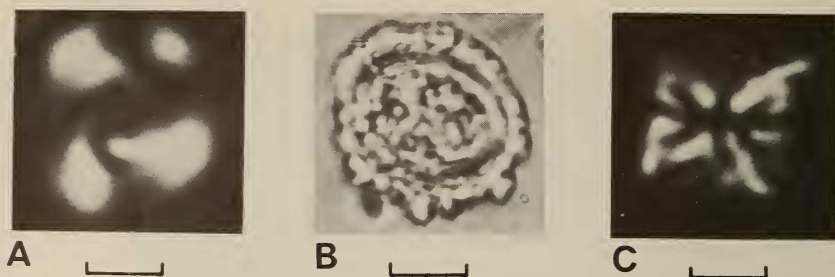


Fig. 8. Calcareous nannofossils from Needs Camp upper quarry (probably Eocene). A. *Cyclococcolithus gammatum*, crossed nicols, scale =  $3\mu$ . B. *Chiasmolithus solitus*, plane polarized light, scale =  $5\mu$ . C. *Micula stauophora* (Gardet) Stradner (reworked from Upper Cretaceous), crossed nicols, scale =  $3\mu$ .

*C. cf. C. formosus* (Kamptner)

*Cyclococcolithus gammatum* Bramlette & Sullivan

? *Cyclicargolithus floridanus* (Roth & Hay)

*Reticulofenestra coenura* (Reinhardt)

? *Zygrhablithus bijugatus* (Deflandre)

No identifiable planktic foraminifers were found in the samples.

#### Age

An unequivocal age cannot be assigned because of the obvious reworking and the questionable identification of several species. Nevertheless, the overall assemblage is clearly Palaeogene (Eocene–Oligocene) (see *Birbury* p. 144 for the age ranges of these species). The age is probably Eocene. *Cyclococcolithus gammatum* is considered by most (but not all) nannofossil workers to be limited to the Eocene; *Toweius* sp. is not considered to range above the lower Eocene (Bukry 1973; Gartner 1977); and *Chiasmolithus solitus* is restricted to the lower and middle Eocene (Gartner 1977).

#### ZULULAND

Scattered outcrops of Tertiary limestones occur in north-eastern Natal ('Zululand'), from the Umfolozi River northward to the Mozambique border and beyond. The best-known exposures are at Uloa, Sapolwana, Warners Drain, Lot U-178, Umkwelane Hill and The Jungle (Fig. 1). Detailed studies of these outcrops have been made by King (1953 et seq.) and Frankel (1960 et seq.). Lesser-known exposures occur at or near Mtoti Pan, Lakeview, Morrisvale and Mkuze. The last two are previously unreported Tertiary localities. Their co-ordinates are: Morrisvale— $27^{\circ}40'36''S$   $32^{\circ}22'03''E$ ; Mkuze— $27^{\circ}33'50''S$   $32^{\circ}15'25''E$ . B. du Cann (pers. comm. 1976) believes the Zululand limestones may reach their thickest development (about 15 m) at Lakeview; Truswell (1977), however, has reported up to 60 m of the limestones at an unspecified



locality in Zululand. In general, these rocks consist of a basal nodular limestone which rests on a planed Cretaceous surface. The nodular limestone contains phosphatized pebbles of Cretaceous siltstone and is intensely iron-stained at some localities. Reworked Eocene foraminifers and Cretaceous ammonites have also been found in this unit (Frankel 1968; King 1970). The basal unit is not everywhere present, but does occur at Uloa, where it is overlain by an unbedded calcirudite ('*Pecten* bed') (Fig. 9). The *Pecten* bed is a richly fossiliferous unit which has yielded over 100 species of macrofossils and 45 species of microfossils (King 1970). The fossil assemblage is dominated by the abundant *Aequipecten uloa* King. The *Pecten* bed is the oldest unit exposed at some localities, but is always overlain by bedded, upward-fining calcarenites (Frankel (1966) gives a detailed description of the lithology of the Uloa section).



Fig. 9. *Pecten* calcirudite at Uloa (upper Miocene to lower Pliocene). Hammer lies above nannofossil-bearing zone.

The stratigraphic position of these outcrops has been the subject of considerable discussion (see Stapleton (1977) for a review). Briefly, King (1953 et seq.) believes the basal and *Pecten* beds are lower Miocene, based on macro- and microfossil evidence. He states that an unconformity separates the lower Miocene unit from the overlying calcarenites, which he dates as Pliocene on the basis of mollusc fragments. Frankel (1968) prefers a middle or upper Miocene to Pliocene position for these limestones, based on sharks' teeth and foraminifers. He recognizes intra-formational channelling of the *Pecten* bed, but not a major hiatus.

Much of the controversy concerning the age of these outcrops resulted from the use of fossils which are not closely age-diagnostic. Two recent papers described assemblages of planktic foraminifers which may have settled the question. Maud & Orr (1975) reported a stratigraphic sequence in boreholes at Richards Bay that is the lithologic equivalent of the Uloa-Sapolwana sequence. The Richards Bay strata consist of a mollusc-fragment coquina (containing ferruginous Cretaceous siltstone pebbles at its base) overlain by quartzose calcarenite. The lowermost portion of the calcarenite consists of well-bedded coarse sand, whereas higher up the calcarenite is cross-bedded. This sequence unconformably overlies Cretaceous and Paleocene rocks and has a maximum thickness of 5 to 6 m in the Richards Bay area. A good assemblage of upper Miocene benthic and planktic foraminifers is found in the calcarenite (Maud & Orr 1975). The foraminiferal assemblage in the coquina is apparently not as age-diagnostic, although Maud & Orr (1975) feel the similarities between the calcarenite and coquina assemblages are sufficient to place the coquina in the upper Miocene also.

Stapleton (1977) found an assemblage of thirteen species of planktic foraminifers in a sample collected at the base of the Uloa *Pecten* bed. He concluded that its age is latest Miocene, or at the Miocene-Pliocene boundary. He reassessed published information on the planktic foraminifers in the overlying calcarenites and concluded that they could be little younger than the *Pecten* bed, and are probably of nearly the same age.

#### *Calcareous nannofossils* (Fig. 10)

Samples examined from Sapolwana, Warners Drain, Umkwelane Hill, The Jungle, Mkuze and Mtoti Pan were barren of nannofossils. Samples from Lakeview, Morrisvale and Lot U-178 contain rare to sparse, poorly preserved specimens of *Reticulofenestra pseudumbilica* (Gartner). A soft pocket in the *Pecten* bed just south of the railway line at Uloa yielded a sparse, but moderately well-preserved assemblage including *Coccolithus pelagicus* (Wallich), *Discoaster surculus* Martini & Bramlette, *Discoaster* sp. and *Reticulofenestra pseudumbilica*.

#### *Planktic foraminifers* (Figs 10-12).

The only samples containing identifiable planktic foraminifers are those from Lakeview, Lot U-178 and Uloa. *Globigerinella aequilateralis* (Brady) and



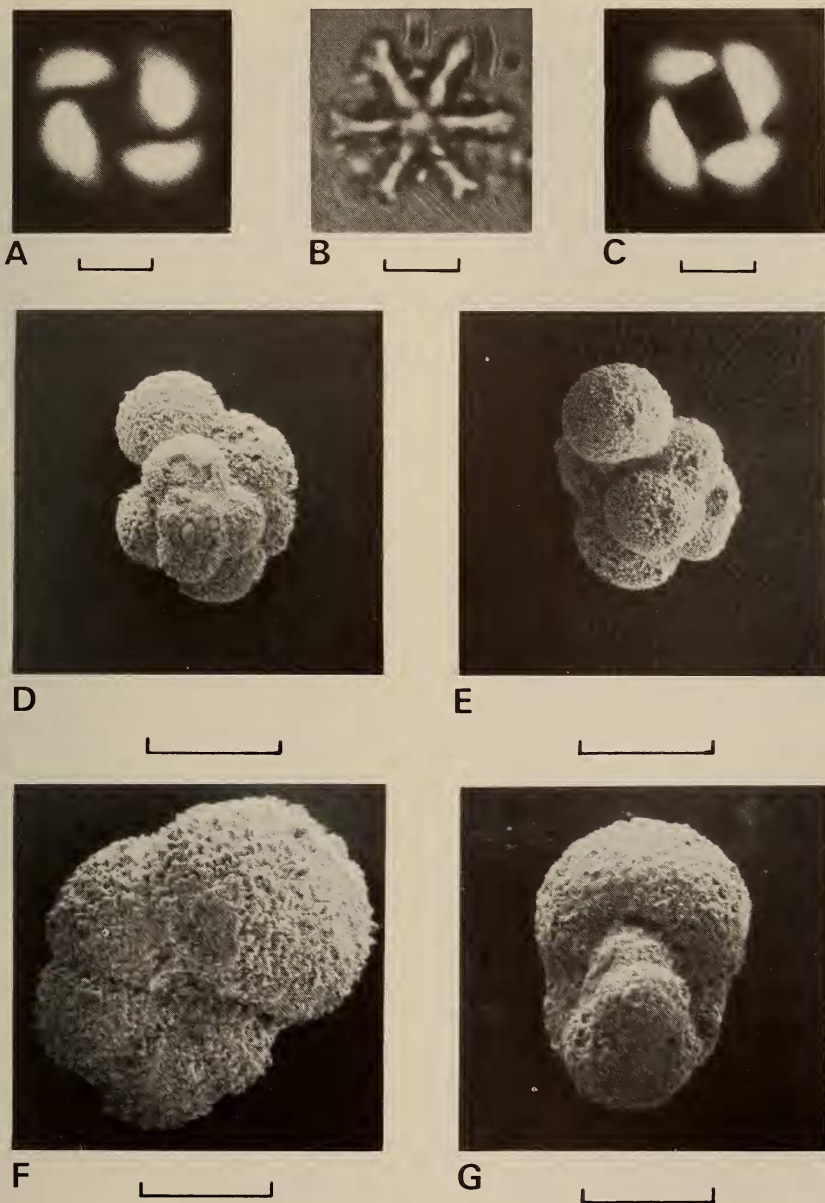


Fig. 10. A-C. Calcareous nannofossils from Morrisvale (A) and Uloa (*Pecten* bed) (B & C), upper Miocene-lower Pliocene. A. *Reticulofenestra pseudumbilica*, crossed nicols, scale =  $3\mu$ . B. *Discoaster surculus*, plane polarized light, scale =  $8\mu$ . C. *Reticulofenestra pseudumbilica*, crossed nicols, scale =  $3\mu$ . D-G. Planktic foraminifers from Uloa (*Pecten* bed). Scales =  $200\mu$ . D-E. *Globigerina* cf. *G. praedigitata*. D. Spiral view, SAM-K5556. E. Side view, SAM-K5556. F-G. *Globigerinella aequilateralis*. F. Spiral view, SAM-K5557. G. Side view, SAM-K5558.

*Globigerinoides obliquus extremus* Bolli & Bermudez were found at Lakeview and *G. trilobus* (Reuss) at Lot U-178. The *Pecten* bed at Uloa yielded a better assemblage, including:

*Globigerina* cf. *G. praedigitata* Parker (single specimen)  
*Globigerinella aequilateralis* (Brady)  
*Globigerinoides conglobatus* (Brady)  
*G. obliquus extremus* Bolli & Bermudez  
*G. trilobus* (Reuss)  
*Globoquadrina altispira altispira* (Cushman & Jarvis)  
*G. altispira globosa* Bolli  
*Neogloboquadrina humerosa* (Takayanagi & Saito)  
*Orbulina universa* d'Orbigny

This assemblage is indicative of warm-temperate water.

#### Age

The calcareous nannofossils and planktic foraminifers in these rocks strongly support the stratigraphic position assigned to them by Maud & Orr (1975) and Stapleton (1977), i.e. upper Miocene to lower Pliocene.

The calcareous nannofossil *Reticulofenestra pseudumbilica* ranges from middle Miocene to lower Pliocene; *Discoaster surculus* ranges from upper Miocene to upper Pliocene. Overlapping age ranges of these two species indicate that the *Pecten* bed at Uloa is upper Miocene to lower Pliocene. Furthermore, the *Pecten* bed can be placed in Martini's (1971) calcareous nannofossil Zones NN 11–NN 15 (9,5 to 3,0 m.y.B.P.; years from Vail *et al.* (1977)).

The planktic foraminiferal assemblage also indicates an upper Miocene to Pliocene assignment. A Pliocene age may be suggested by the presence of *Globigerinella aequilateralis* and *Neogloboquadrina humerosa*, since these species are substantially more abundant in the Pliocene than in the Miocene, and thus are more likely to be encountered in sparse Pliocene, rather than in sparse Miocene, samples. However, this is very tenuous 'evidence', and only the conservative range of upper Miocene–lower Pliocene is assigned at this time.

#### TERTIARY SEA-LEVEL MOVEMENTS

The firmly dated limestones at Birbury (lower Eocene) and in Zululand (upper Miocene–lower Pliocene) and the tentatively dated limestones at Needs Camp (Eocene) provide evidence as to the timing of sea-level movements round the south and east coasts of South Africa.

Siesser & Dingle (1979) presented a generalized scenario of Tertiary sea-level movements round southern Africa, based on evidence from continental shelf and on-shore deposits. They suggested that a transgression began in mid Paleocene times and continued into the early Eocene. A middle Eocene regression was followed by another transgression in the late Eocene (see also Siesser 1977).

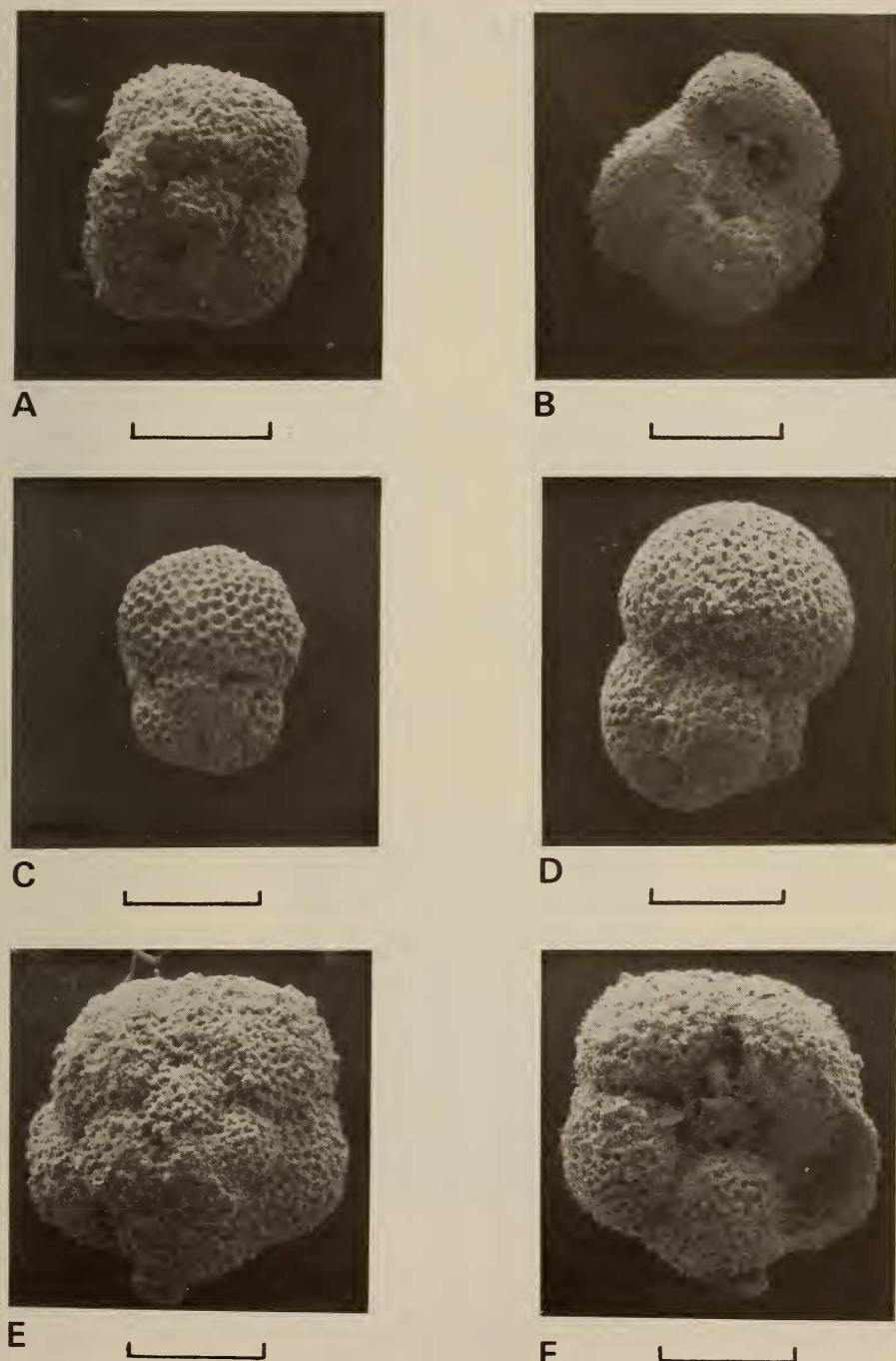


Fig. 11. Planktic foraminifera from Uloa (*Pecten* bed) (A, C-F) and Lakeview (B), upper Miocene-lower Pliocene. A. *Globigerinoides conglobatus*, spiral view, SAM-K5559. B. *G. obliquus extremus*, umbilical view, SAM-K5560. C-D. *G. trilobus*. C. Spiral view, SAM-K5561. D. Umbilical view, SAM-K5562. E-F. *Globoquadrina altispira globosa*. E. Spiral view, SAM-K5563. F. Umbilical view, SAM-K5563. Scales = 200 $\mu$ .

The early Eocene transgression is recorded on-shore by the outcrops at Birbury. The Needs Camp limestones can be dated only as probably Eocene; thus it cannot yet be suggested whether they were deposited during the early or the late Eocene transgression.

Other evidence presented by Siesser & Dingle (1979) indicates that, after a long Oligocene-early Miocene regression, the seas began to move shoreward again in middle Miocene time. This transgression probably reached its greatest extent in the late Miocene-early Pliocene, as represented by the sequence of marine limestones in Zululand.

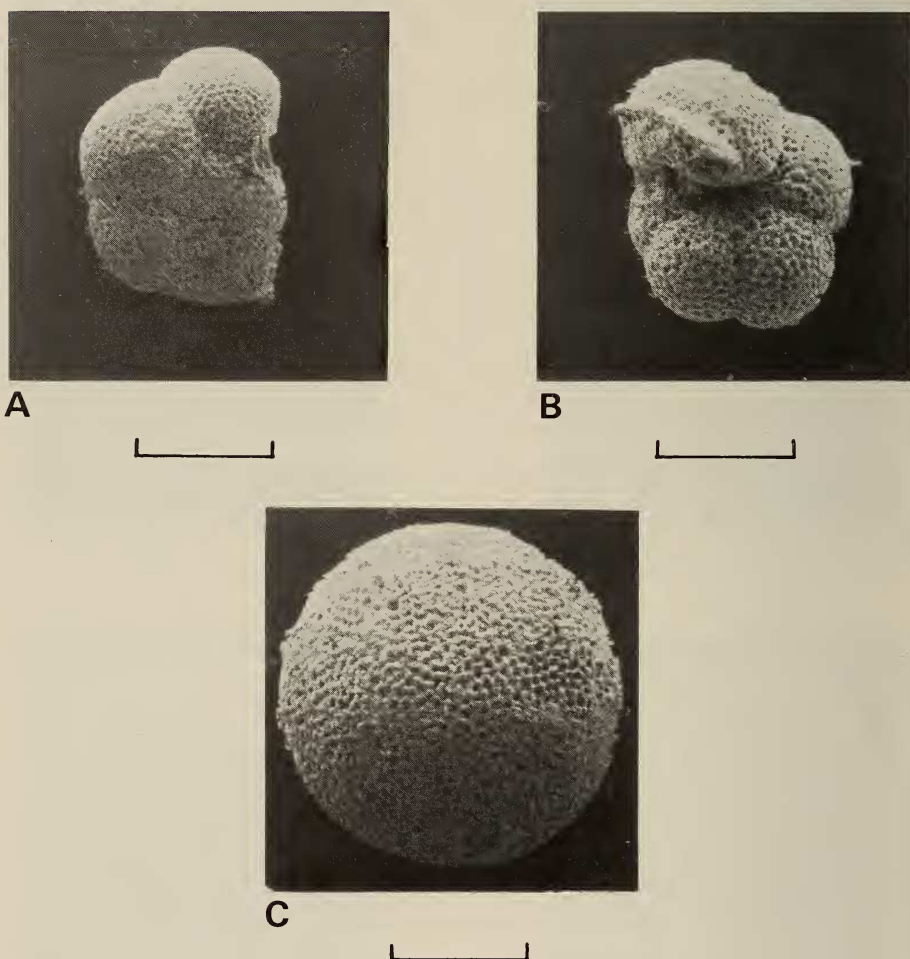


Fig. 12. Planktic foraminifera from Uloa (*Pecten* bed), upper Miocene-lower Pliocene. A-B. *Neogloboquadrina humerosa*. A. Spiral view, SAM-K5564. B. Umbilical view, SAM-K5565. C. *Orbulina universa*, SAM-K5566. Scales = 200 $\mu$ .



## ACKNOWLEDGEMENTS

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Dr H. C. Klinger directed one of us (WGS) to previously unreported Tertiary outcrops in Zululand (Morrisvale and Mkuze). His assistance is gratefully acknowledged. Scanning electron microscopy of the foraminifers was funded by Exxon Company, U.S.A.

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